**OPTICAL CONSTANTS OF AMORPHOUS WATER ICE IN THE NEAR-INFRARED.**
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**Introduction**

At low temperatures and pressures pertinent to surfaces in the outer solar system water ice can exist in a number of metastable phases [1,2]. If water vapor is condensed at temperatures below about 100 K, then a variety of amorphous phases ($I_a$) may be formed [2]. If the vapor is deposited at temperatures of 120-140 K, or the amorphous ice is warmed to these temperatures, then an irreversible exothermic phase transition to cubic ice ($I_c$) occurs [1,2]. At higher temperatures, 140-220 K, cubic ice undergoes an irreversible exothermic phase transition to hexagonal ice ($I_h$) [1,2].

The sub-solar temperature range of objects in the outer solar system includes the relatively balmy Galilean satellites (130-170 K), the saturnian satellites (100-120 K), the uranian satellites (~80 K), and the frigid regions of Neptune's moon Triton (~35 K), along with Pluto and it's moon Charon (~40 and 55 K, respectively). Polar temperatures are even lower on many of these objects. These temperatures suggest the ability to form various phases of water ice on these surfaces both in the current epoch and perhaps in past epochs as well.

Infrared transmission spectra of these various phases of water ice show that the phase transitions are accompanied by distinctive spectral changes [1,2,3,4]. Because the water ice absorption features seen in the near-infrared reflectance spectra of surfaces throughout the outer solar system are overtone and/or combination modes of the infrared fundamentals, they should also exhibit spectral variability that can be associated with the phase of water ice present [1]. This would provide a mechanism of remotely recognizing these various water ice phases and thus provide information regarding the temperature history of such surfaces [1].

Past and continuing near-infrared telescopic spectral observations of these surfaces shows ample evidence for water ice, specifically $I_h$ at low temperatures [5,6,7]. These observations sample the entire earth-facing disk and as a result can not distinguish latitudinal variations in the phase of water ice. Observations by the Galileo NIMS [8] or by NICMOS on HST may provide the ability to investigate latitudinal variations in the water ice signatures of some of these distant objects. Compositional interpretation of such spectral observations relies upon modeling the interaction of sunlight with the surfaces and these models require the optical constants of the pertinent materials [9,10,11,12,13]. Previously the optical constants of $I_h$ at low temperatures were reported [4,14]. Here the optical constants of amorphous ice are presented.

**Approach & Results**

The transmission (T) measurement of a thick film of amorphous ice (82 K) at near-infrared wavelengths [15] were digitized and the quoted sample thickness (d) was used to calculate the absorption coefficient (a) using Beer's law, $T=(I/I_o)e^{-ad}$. The absorption coefficients were used to calculate the imaginary indices of refraction via the dispersion relationship. These results were combined with the imaginary index data at longer wavelengths [16]. Using the reported visible real index of refraction for water ice at low temperatures and pressures [17], a subtractive Kramers-Kronig analysis was performed to derive the real index of refraction.

**Comparisons to Other Studies**

At near-infrared wavelengths, the imaginary index of $I_h$, at low temperatures (~100 K) [4,14], exhibits more spectral structure than that of $I_a$. This is consistent with transmission studies of the two phases at longer wavelengths and the associated crystalline differences between the two phases. The imaginary indicies near 1.5 and 2 micrometers of $I_a$ are similar to those previously reported for $I_h$ [18].

The derived real index of refraction of $I_a$ is signifinicantly less than that previously reported for $I_h$ at any temperature. This is a direct result of using the real index reported at low temperatures and pressures [17].

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